was found to have n=30 chromosomes, which neatly fills an important gap in the polyploid series of *M. glabratus* var. *utahensis*, n=15, to *M. glabratus* var. *parviflorus*, n=45. Lastly, one race of South American *M. luteus* has n=32 chromosomes, as had been previously reported for its horticultural derivatives, but the other race apparently has n=30+0, 1, or 2.

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FLOWERING RESPONSES IN PHACELIA SERICEA AND P. IDAHOENSIS[1]

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In the study of variation in the *Phacelia sericea* complex [*P. sericea* (Graham) A. Gray subsp. *sericea*; *P. idahoensis* Henderson; and intermediates], experimental cultures of *P. sericea* subsp. *sericea* and of *P. idahoensis* could not be brought into flower under actual or simulated summer conditions. In these cultures, the daily photoperiod was extended by incandescent lights, when necessary, to between 16 and 20 hours. Later cultures were brought into flower, however, by simulating the fall conditions of the natural environment to the extent of materially reducing

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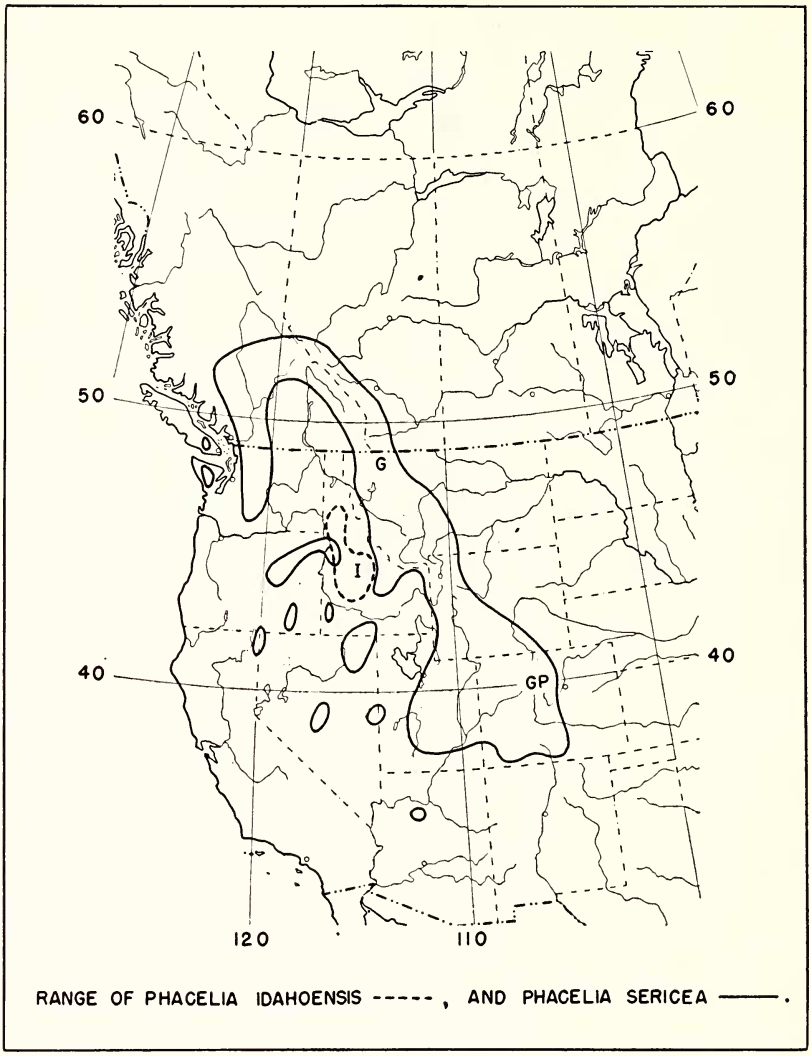

FIG. 1. Geographical distribution of *Phacelia sericea* and *Phacelia idahoensis*. Races employed in experimental cultures: *P. idahoensis* (I), Valley Co., Idaho. *P. sericea* subsp. *sericea*: (G), Glacier Co., Montana; (GP), Routt Co., Colorado. Base map courtesy of University of Chicago Press.

the length of the photoperiod and, at the same time, providing a cool temperature regime (Table 1). The data obtained from these cultures could be of value to those interested in growing alpine perennials experimentally, inasmuch as they show that certain alpines can be manipulated into flowering in a relatively short time.

Both *Phacelia sericea* and *P. idahoensis* are spring-flowering perennials.

Early growth in each species is marked by the formation of a leaf rosette at ground level, with a virgate inflorescence axis later arising from the center of the rosette. In respect to geographical distribution (fig. 1), P. *sericea* occurs in the Rocky Mountains, the northern Cascades, the Olympics, and the ranges of the northern Great Basin. It is common at higher elevations, occurring on exposed gravel banks and talus slopes from 4500 feet, in the Canadian Rockies, to 13,000 feet in southern Colorado. By contrast, *P. idahoensis* is restricted to central Idaho, where it is found between 2800 and 7000 feet on wet meadows, stream banks, and on bottomlands subject to seasonal flooding.

Limited field studies made on colonies of *Phacelia sericea* subsp. *sericea* have produced some information about the flowering response in this cordilleran subspecies. In several colonies examined in Colorado, Wyoming, and Montana, there was a pronounced tendency for early summer flowering, and for the simultaneous expression of a given phase of flowering by both large and small plants within a given colony. Furthermore, widely-separated colonies that were examined on the same day exhibited similar stages of inflorescence development. These points were convincingly emphasized by an extensive and unsuccessful search for meiotic flower buds in several flowering colonies in Glacier County, Montana. In this area, and in Park County, Wyoming, colonies separated by as much as 1000 feet of elevation were found in similar stages of flowering.

The examination of collection data from over 800 herbarium sheets of *Phacelia sericea* and *P. idahoensis* confirmed the above field observations. In both species, there is a very strong tendency to early summer flowering, and general uniformity in the stage of inflorescence development in specimens of a given collection. The sum total of this evidence would, therefore, suggest that flowering in these species is "triggered" by a broadly imposed environmental stimulus or stimuli, and it would tend to rule out the possibility that these are day-neutral species.

Three races of these species were included in the present study. They were grown in experimental cultures (see Table 1) from seed collected in the following localities:

Phacelia sericea subsp. *sericea*

Gore Pass. Newly-graded road shoulder, highway 84, Routt County, Colorado, 9.9 miles west of Gore Pass, elevation ca. 8000 feet, *Gillett 1145* ("GP" in fig. 1).

Glacier. Gravel road shoulder, 0.8 miles west of Many Glacier Entrance Station, Glacier National Park, Glacier County, Montana, elevation 4800 feet, *Harry Robinson s.n.* ("G" in fig. 1).

Phacelia idahoensis

Moïst bottomlands 2.9 miles south of Donnelly, Valley County, Idaho, elevation 4800 feet, *James Hockaday s.n.* ("I" in fig. 1).

Voucher specimens of experimental plants have been deposited at the herbaria of Michigan State University and the University of California, Berkeley.

Table 1. Flowering responses in Phacelia idahoensis and P. sericea

I. Plants given *long-day cycles only.*

A. Approximately 155 long-day cycles between October and March, 18–20 hour photoperiods. Temperatures between 10° and 25°C.

	No. Plants	*Flowered*
P. idahoensis	9	0
P. sericea (Gore Pass)	8	0
P. sericea (Glacier)	5	0

B. Approximately 180 long-day cycles between April and September; with 14–16-hour photoperiods. Temperatures between 15° and 30°C.

P. idahoensis	20	0
P. sericea (Gore Pass)	10	0
P. sericea (Glacier)	10	0

C. Approximately 250 long-day cycles between February and October; with 14-16-hour photoperiods. Temperature between —3° and 35°C.

P. idahoensis	8	0
P. sericea (Glacier)	4	0

II. Plants given *long-day cycles (14–16 hr. photoperiods) followed by short-day cycles.*[a]

A. Approximately 110 long-day cycles (temp. regime of I.-C) followed by 23 short-day[b] cycles terminated by 22 cycles of 16-hour photoperiods under 14°C. days and 7°C. nights, the 155-days-old plants then placed in a greenhouse (mid-July), with no supplementary light.

	No. Plants	*Flowered*	*Days to flowering after short-day treatment*
P. idahoensis	8	8	16
P. sericea (Glacier)	4	2	12

B. Approximately 163 long-day cycles (temp. regime of I.-C) followed by 65 short-day[c] cycles, the 228-days-old plants then placed in a greenhouse (mid-September), with no supplementary light.

P. idahoensis	3	3	19
P. sericea (Glacier)	2	1	16

C. Approximately 169 long-day cycles (temp. regime I.-C) followed by 59 short-day[c] cycles, the 228-days-old plants then placed in a greenhouse (mid-September), with no supplementary light.

P. idahoensis	3	3	23
P. sericea (Glacier)	2	1	23

[a] short-day cycles given inside a walk-in refrigerator with incandescent lights under temperature regime of 14°C. days and 7°C. nights.

[b] 10-hour photoperiods.

[c] 8-hour photoperiods.

Culture techniques included germinating seeds in moist vermiculite, then transplanting young (ca. two weeks old) seedlings to four-inch pots holding equal parts of sterilized, screened river sand and peat moss. The plants were fed a nutrient solution (2 oz. commercial fertilizer per gallon of tap water) once a week through a siphon connection to the watering hose.

The light and temperature regimes provided for these cultures are given in Table 1. The results obtained indicate that *Phacelia sericea* subsp. *sericea* and *P. idahoensis* are neither day neutral nor "nominal" long-day plants. The positive flowering responses obtained in all cultures given the combination of cool temperatures and short photoperiods would suggest that these are obligate short-day species; although the possibility of their being conditioned for flowering by low temperatures, independent of day length, remains very strong.

In a final experiment, seven plants of *Phacelia idahoensis* that had been held to long photoperiods of from 14 to 16 hours for 264 days were placed in an open cold frame and exposed to the late fall light and temperature regime of central Michigan. These conditions included temperatures ranging from +10° to −10°C. After 37 days of "outside" weather, these plants, the pots frozen solid, were removed to the greenhouse. Six of the seven plants produced inflorescences and flowered within a month. These inflorescences were formed in a greenhouse where unaltered December lighting conditions prevailed, demonstrating (as indicated in II-C of Table 1) that this species does not require, subsequent to induction, a long-day regime for flowering. It would seem practicable, therefore, to culture this species by a schedule that would include spring germination, and a fall induction period under a cool temperature regime, with the prevailing light of approximately 40° north latitude. It is probable that these suggestions also apply to *P. sericea* subsp. *sericea* inasmuch as its flowering response is similar. A close relationship is indicated by the genetic compatibility between the two taxa, the F_1 hybrids being highly fertile and also flowering after short-day induction treatments.

In addition to providing knowledge for the successful culture of these and probably other species of alpine perennials, these experiments leave a pointed suggestion for plant geographers, namely, that *Phacelia sericea* subsp. *sericea*, a northern alpine perennial, has, in terms of photoperiod requirements, southerly rather than arctic affinities. This would not be surprising in view of the fact that the great bulk of *Phacelia* species are found south of 40° north latitude, while only two species occur farther north than *P. sericea* subsp. *sericea*.

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REVIEWS

Illustrated Flora of the Pacific States. Washington, Oregon, and California. Volume IV—Bignoniaceae to Compositae. By Roxana Stinchfield Ferris. xiii + 732 pages, 1124 figures, and an appendix (for all four volumes) with key to families, index to common names, and index to scientific names. Stanford University Press, Stanford, California. 1960. $17.50.

In 1923, with the publication of Volume I, Ophioglossaceae to Aristolochiaceae, of the "Illustrated Flora of the Pacific States," Leroy Abrams launched his life's work—an illustrated, descriptive flora of all vascular plants known to grow wild in the three Pacific states—Washington, Oregon, and California. Now, thirty-seven